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The Analysis of Three-Tubed Variations of Hot Air as a Coffee Bean Dryer

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ABSTRACT

One of methods to process coffee beans is carried out by drying and during this period, drying by mechanical and/or artificial devices is meant to overcome the deficiencies of drying in the sun. In this study, coffee beans were dried in the oven-style dryer, utilizing hot air from a furnace. The purpose of this study is to investigate how good the number of holes is to dry coffee beans using hot air. The hole variations were about 300, 350, 400 holes. This study shows that the drying time was two hours for drying coffee beans using hot air; the water content of coffee beans reduced to 37.67%, while, initially, the coffee moisture is about ± 60%. Hence, the drying process was noted as efficient with the percentage efficiency was 36.68%. The best numbers of holes for efficient variations were about 400 holes and the moisture of final content in the coffee beans was recorded to 38.59%.

Keywords: Analysis, Dryer, Beans, Coffee, Hot air

INTRODUCTION

To dry coffee beans has been known since long time ago using material preservation method. The basic objective of drying is to reduce the moisture content of beans thermally to a certain level, where damages caused by microbes and chemical reactions can be minimized, so that the quality of beans can be maintained. Drying coffee is related to a process to reduce the water content and its purpose is have the best bean quality. Drying has two methods, namely natural and artificial drying. The first one depends on the weather and requires human labours during the drying.

Coffee bean dryer with hot air is very suitable for drying coffee beans because the beans are dried by utilizing a stream of hot air at a certain speed that is passed through the dryer so that the materials have fluid-like properties. In this research, modelling hot fluid is done by combustion of hot air. The flow of hot air in the drying chamber takes place forcibly with the help of a blower. Therefore, the distribution of hot air flow is designed through each drying rack. There are three number of shelves in the drying chamber. Each shelf is filled with small holes, and the drying process was carried out in rotation (rotary). The problem that often occurs in this dryer is related to the inefficient heat distribution which affects the length of the drying time, so it is necessary to pay attention to the model of holes on each shelf, as well as to the number of efficient holes to speed up the drying of the beans and the materials that can conduct heat. Heat is well combined with the mass flow rate with the specific heat of the fluid so that it becomes a single quantity called the average heat capacity.

In the process of making the coffee bean drying machine, this research is limited to working mechanism of coffee bean dryer, the power required by the engine, and the drying mechanism by hot air. The research is aimed at the working mechanism of the coffee bean drying machine, the variation in temperature needed to dry the beans, the capacity of dried beans, and the amount of fuel needed.

LITERATURE REVIEW

Drying is the evaporation of water into the air due to differences in the moisture content between the air and the material being dried. In this case, the water vapor content of the air is less or the air has low relative humidity so that evaporation occurs.[1] The ability of air to carry water vapor increases if the difference between the relative humidity of the drying air and the surrounding air increases. One of the factors that speeds up the drying process is the speed of the wind or flowing water. Water that does not flow causes the water vapor content around the dried material to become more saturated, so drying is more sluggish. Air humidity affects the process of removing water vapor. If the air humidity is high, the difference in vapor pressure inside and outside becomes small so that it inhibits the transfer of water vapor in the material to the outside. The ability of the material to release water from the surface is greater when the increasing temperature of the drying air happens. An increase in temperature also causes a small amount of heat needed to evaporate the materials in the water. [1]

The ability of air to carry water vapor increases if the difference between the relative humidity of the drying air and the surrounding air is greater.[2] One of the factors that speed up the drying process is the speed of the wind or flowing air. Air that does not flow causes the water vapor content around the dried materials to become more saturated so that drying is slower. Air humidity affects the process of removing water vapor. If the air humidity is high, the difference in vapor pressure inside and outside becomes small so that it inhibits the transfer of water vapor in the materials to the outside.[3] The ability of the materials to release water from the surface becomes greater because of the increasing temperature of the drying air. The increase in temperature also causes a small amount of heat needed to evaporate the material's water.[4]

According to Rohman, drying is the process of removing a number of pairs from the materials.[5] In drying, water is removed by the principle of the difference in humidity between the drying air and the materials being dried. The materials are usually contacted with dry air which then transfers the mass of water from the materials to the drying air. The purpose of drying is to reduce the moisture content of the materials to the extent that the development of microorganisms and the activity of enzymes that can cause decay are inhibited or even completely stopped. Thus, the dried materials have a longer shelf life.[1]

According to Momo, there are two main factors affecting drying process, such as, factors related to drying air and the nature of the materials.[6] In case of factor related to drying air, there are four points that should be paid as attention, namely, temperature (the higher the air temperature, the faster the drying will be), air flow rate (the faster the air, the faster the drying will be), humidity (the more humid the air, the slower the drying process), and air flow direction (the smaller the angle of the air direction to the position of the material, the faster the material dries). Regarding factor related to the nature of the materials, two aspects can be considered, for instance, material size (the smaller the size of the material, the drying will be faster), and water content (the less water it contains, the faster the drying will be).

MATERIALS & METHODS

Test tool design

In this study, the tools are first designed according to the theoretical basis in which the research materials should be available in the market. The tool design is made as simple as possible and the tool measurement should be precise since this tool is used for testing and for data collection for specific combustion processes. The way this tool works is to utilize hot air from the furnace, by first putting the palm shell fuel and by turning on the fire to heat the pipe in the furnace. The hot air blower from the pipe in the furnace is pushed into the drying cupboard through the distribution pipe and then through the existing hot air pipe. Inside the drying chamber, there is a hole for hot air to escape, along with a rotating drying rack with a motor drive so that air enters through the holes on each shelf wall.

Experimental method

Experimental methods might include preparation and tests. Before conducting the research, preparations are made first, for instance, conducting a literature study to plan what is researched and providing material measuring tools and equipment which are done by making survey to the materials needed. Conducting tests on coffee beans can be performed by estimating the length of time needed to reduce the water content in the beans in order to get effective results. The tests might include the look at the changes occurring in the beans and the length of time used in the drying process, and the consideration of number of beans which greatly affect the results of the experiment because the more beans are dried, the longer it takes to reduce the water content of the beans.

Observed variables

This research was conducted in three kinds of experiments, namely, length of time, temperature, and efficiency; all these three should be oriented to the water content reduction of the beans. All tools are characterized as the path of hot air from the furnace through the pipe. The variables observed in this study are to reduce bean water content, to know the effect of hot air after drying the combustion products, and to examine the variations in the holes on the drying rack.

Test procedures

Test procedures include the initial preparation, placement, and assembly of the test equipment according to the design drawings for the calibration process and data collection. The procedures for carrying out the tests involve the burning furnace as a source of heat which is aimed at reducing the bean water content, screwing to transfer fuel to the combustion furnace, and carrying out a test equipment experiment to determine the quality of hot air produced from a kiln to reduce the moisture content of beans.

RESULT AND DISCUSSION

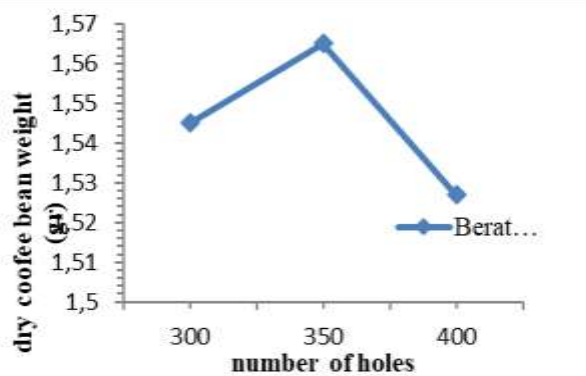

Figure 1. Effect of temperature on the variation of number of holes

Tabel 1. Temperature influence on the variation of number of holes

No	Number of holes	Average Temperature (℃)
1	300	65 ℃
2	350	70℃
3	400	72℃

Fig. 1 shows that the average temperature is 65℃ on 300-hole rack pipe, 70℃ on the 350-hole rack, and 72℃ on the 400-hole rack pipe. The greater number of holes are available, the faster the beans are dried.

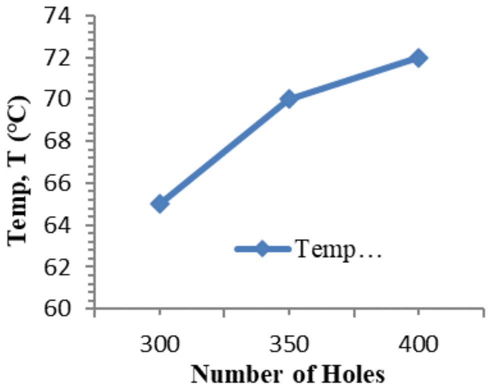

Figure 2. Effect of number of holes on beans drying

Tabel 2. Effect of number of holes on drying beans

No	Number of holes	Dry bean weight (Kg)
1	300	1,545
2	350	1,565
3	400	1,527

Fig. 2 displays that for 400 holes, the initial drying of beans is 2,000 Kg, reduced to 1,565 Kg for 350 holes, and then increased to 1,527 Kg for 400 holes. For 400 holes, more hot air flows into the 400 racks; hence, the more hot air flows into the rack, the more the bean's moisture content decreases.

Tabel 3. Drying efficiency by number of holes

No	Number of holes	Drying Efficiency (%)
1	300	15,05
2	350	19,76
3	400	21,46

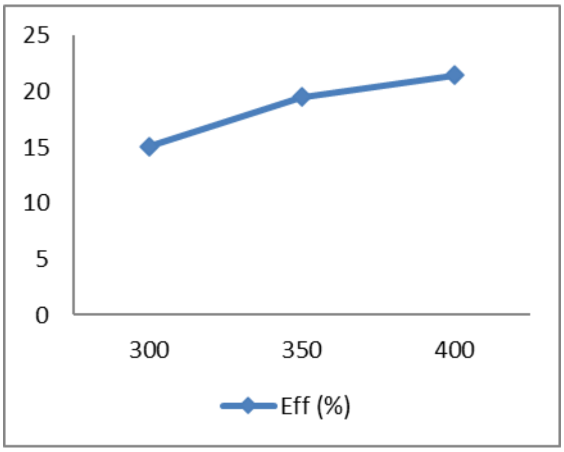

Figure 3. Graphic of drying efficiency by number of holes

Fig. 3 indicates that the drying efficiency for 400, 350, and 300 holes is 21.46%, 19.49%, and 15.05% respectively. Hence, the more holes are available in the rack, the hotter the air flows through the holes, and the fewer holes exist, the less hot the air enters the rack.

CONCLUSION

After results and discussion is made, the author concludes that in rack with 300 holes, it is 1592.7 KJ, with a drying efficiency of 15.05%, and the reduced water content of beans is 37.67% from the initial assumption that the water content of beans is ± 60%, so the final water content of beans produced is 22.33 %. In rack with 350 holes, it is 1031.6 KJ, with a drying efficiency of 19.49%, and the reduced water content of beans is 36.68% of the assumed moisture content of beans is ± 60%, so the final water content of beans produced is 23.32 %. For 400-hole rack, it is 1119.2 KJ, with a drying efficiency of 21.46% and the reduced moisture content of the coffee beans is 38.59% from the assumed moisture content of the coffee beans is ± 60%, so the final moisture content of beans produced is 21.41%. Two hours are spent for fuel during the drying process of beans of eight Kg with hot air, so, the fuel needed is 0.06 Kg/minute and 2 Kg/hour. For the efficiency of various number of holes in the stirrer tube for drying beans using hot air, three aspects can be noted, such as, for first experiment, in the 400 holes, the drying efficiency is 21.46%, reducing the weight of beans from 2,000 Kg to 1,545 Kg, with a total value of the dried water content is 22.33% from the initial assumption of 60%, and the water content of beans reduces to 37.67%. For second experiment, for 350 holes, the drying efficiency reaches 19.76%, resulting in a reduced weight of beans from 2,000 Kg to 1,605 Kg, with a total value of the dried water content is 25.52% from the initial assumption of 60%, and the water content of beans reduces to 34.48%. In the third experiment, at 300 holes, the efficiency is noted to 15.05%, reducing the weight of beans from 2,000 Kg to 1,527 Kg, with a total value of the dried water content is 26.41% from the initial assumption of 60%, and the water content of beans is reduced to 38.59%. In case of coffee bean drying speed, three points should be considered, for instance, in the first experiment, at 300 holes, the average temperature of drying in the cupboard is 65.6℃, with an initial bean weight is 2,000 kg and the weight of beans after being dried using dryer reduces to 1,545 kg, with drying time for two hours, and with a drying speed is 0.239 kg/hour. During the second experiment, at 350 holes, the average temperature of bean drying in the cupboard is 64.2℃, with an initial bean weight is 2,000 kg and the weight after being dried reduces to 1,605 kg, with the drying time is two hours and at the drying speed of 0.202 Kg/hour. For the third experiment, at 400 holes, the average temperature of bean drying in the cupboard is 60.6℃, with an initial beans weight is 2,000 kg and the weight of beans after being dried reduces to 1,527 kg for two hours with a drying speed is 0.186 Kg/hour.

Declaration by Authors

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Conflict of Interest: The authors declare no conflict of interest.

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